

ENCOURAGING THE PURSUIT OF ADVANCED DEGREES  
IN SCIENCE AND ENGINEERING:  
TOP-DOWN AND BOTTOM-UP METHODOLOGIES

Anthony B. Maddox

Massachusetts Pre-Engineering Program and  
Brandeis University Computer Science Department

Renée P. Smith-Maddox

Massachusetts Pre-Engineering Program and  
Brandeis University Heller Graduate School

Benson E. Penick

Benson Penick & Associates

### ABSTRACT

This paper describes the MassPEP/NASA Graduate Research Development Program (GRDP)<sup>1</sup> whose objective is to encourage Black Americans, Mexican Americans, American Indians, Puerto Ricans, and Pacific Islanders to pursue graduate degrees in science and engineering. GRDP employs a **top-down** or goal-driven methodology through five modules which focus on research, graduate school climate, technical writing, standardized examinations, and electronic networking. These modules are designed to develop and reinforce some of the skills necessary to seriously consider the **goal** of completing a graduate education.

GRDP is a community-based program which seeks to recruit twenty participants from a pool of Boston-area undergraduates enrolled in engineering and science curriculums and recent graduates with engineering and science degrees. The program emphasizes that with sufficient information, its participants can overcome most of the barriers perceived as preventing them from obtaining graduate science and engineering degrees.

Our experience has shown that our top-down modules may be complemented by a more **bottom-up** or event-driven methodology. This approach considers **events** in the academic and professional experiences of participants in order to develop the personal and leadership skills necessary for graduate school and similar endeavors.

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## Introduction

As the United States becomes more technology-based, there is a corresponding growth in the demand for technically-trained people. Some recent demographic projections indicate that approximately 0.75 million technical positions may go unfilled at the beginning of the 21st century. Many of these positions will require research-oriented master's and doctoral degrees, which are increasingly being awarded to individuals who are not citizens of the United States. One way to increase our national resource of technical people is to encourage Americans from racial and ethnic populations who are underrepresented in technical disciplines to pursue engineering and science degrees and careers.

For the past 10 years, the Massachusetts Pre-Engineering Program (MassPEP) has been successfully encouraging Boston and Cambridge middle and high school students from these populations to study engineering and science. Recently, more than 80 percent of MassPEP participants have attended college, many selecting technical majors. Since the Fall of 1986, MassPEP and the National Aeronautics and Space Administration (NASA) have collaborated on the Graduate Research Development Program (GRDP). The goal of GRDP is to encourage Black Americans, Mexican Americans, American Indians, Puerto Ricans, and Pacific Islanders (hereafter referred to as our target population) to pursue research-oriented graduate degrees in engineering and science.

## Top-Down Program Design

GRDP employs a **top-down** or goal-driven methodology through five modules which focus on research, the graduate school process, technical writing, standardized examinations, and electronic networking. These modules are designed to develop and reinforce some of the skills necessary to seriously consider the **goal** of completing a graduate education. GRDP modules were also designed to disseminate information needed when applying to and completing graduate programs in a wide range of technical disciplines.

The modular activities of the GRDP curriculum were generated directly from the program objectives, which are the **subgoals** of the program. They were designed to achieve the objectives over a twelve-week period with four-hour meetings scheduled on Saturday of each week. To accommodate scheduling disparities, GRDP does not emphasize the structure of regular meeting attendance, but instead, places an emphasis on effective time management within the constraints of other commitments.

The objective of the **RESEARCH** module is to expose each participant to the process of developing a technical research proposal. Each participant generates a 5-10 page proposal including abstract and bibliography in an area of interest. An oral presentation is given in an open forum which may include representatives from academia, industry, and government as well as GRDP staff and participants. Generally, undergraduate research opportunities are seized by upperclassmen who have

developed relations with faculty or have exhibited exceptional academic ability. Factors such as social isolation and academic performance can prevent our target population from developing these necessary faculty relationships thus curbing an interest in research. GRDP offers an opportunity to explore a technical research topic of interest.

The **SEMINAR** module's objective is to help each participant develop perspectives on various research opportunities and apply for research internships, admission to graduate research programs, and financial support. Pursuit of a research-oriented experience is illustrated as a planned sequence of activities guided by a thorough investigation of technical interests and objectives. Attention is given to specific strategies, heuristics, and personal development issues. The module's agenda is supported by a booklet published by GRDP entitled **Graduate School in Science and Engineering: IT PAYS TO GO** and discussions with invited speakers. Participants are asked to submit applications to at least two research internship or graduate programs and financial aid sources. All application fees are reimbursed by GRDP.

Success in graduate school involves: (1) academic performance, (2) understanding departmental agendas and procedures, and (3) successfully interacting with colleagues and faculty. GRDP participants learn about the explicit and implicit details of applying to and being successful in graduate programs. There are opportunities for participants to discuss and examine various aspects of the graduate school process. Topics include: matching one's skills with particular academic institutions, the application process, financial support, tenured versus non-tenured advisors, oral versus written qualifying and comprehensive examinations, etc.

The objective of the **COMMUNICATION** module is to provide each participant with practice and experience with communicating written and oral technical information and opportunities to discuss technical issues. Occasionally the module's format includes class discussions pertaining to racial and ethnic issues which can affect graduate students. The result is a completed research proposal and an oral presentation with visual aids. Some undergraduate engineering and science curriculums do not include many courses on writing, though written communication is an essential part of an engineering or science career. GRDP gives its participants the opportunity to develop the writing skills which are necessary for graduate school applications, research reports and papers, etc.

The Graduate Record Examination (**GRE**) module's objective is to reinforce each participant's skill in taking the GRE. Practice GRE General Tests are administered by GRDP while each participant is offered the option of taking an Educational Testing Service (ETS) administered GRE General or Subject Test. Participants are responsible for completing two examinations and the verbal, quantitative, and analytical sections of past examinations as in-class assignments. There are also opportunities to freely discuss individual or group concerns about the GRE. All GRE registration fees are reimbursed by GRDP. The rationale is that if practice improves GRE scores, the chances of being accepted into graduate school also improve.

The objective of the **COMPUTER** module is to reinforce the use of computers as an essential means to support research and as an effective means to maintain professional networks for each participant. Participants have the opportunity to use electronic bulletin boards and mail to reinforce networking. The major concern of GRDP participants is that the program will interfere with their academic or work schedules. Computer-based communications allow staff and participants to interact when personal contact is not possible. This "electronic mentoring" also helps participants and staff become more familiar with the use of computers, terminals, and modems.

## **Participants**

GRDP is a community-based program which seeks to recruit twenty participants from a pool of Boston-area undergraduates enrolled in engineering and science curriculums and recent graduates with engineering and science degrees. We have found that recent graduates, those who have received their degrees within the past five years, have been the most consistent participants in GRDP. Two possible reasons are that: (1) their employment schedules do not interfere with GRDP activity as much as the academic schedules of undergraduates and (2) their experience has shown them the value of an advanced degree.

## **Admission**

Recent graduates are accepted for admission if they have a bachelor's or master's degree in engineering or science. Undergraduates (excluding freshmen) are admitted as long as they meet the minimum academic requirements for their academic institution. One of the strongest messages sent by the program was that there is no reason not to consider a graduate degree in engineering or science. GRDP is committed to showing its participants how they could use a variety of strategies for overcoming many apprehensions based on their academic or personal histories. Though GRDP maintains that standardized examination scores and other factors such as research experience may strengthen an average undergraduate record, we acknowledge that there are few substitutes for above average academic performance.

## **Benefits**

In addition to paying graduate school application and GRE fees, GRDP provides the use of a modem and personal computer or terminal for networking. This has proven to be helpful to participants who access computers regularly in their work or studies. A \$200 stipend is also awarded to participants who complete two GRE examinations, give an oral presentation on their written research proposal, and submit two research internship or graduate school applications. For partial completion of program activity, a pro-rated amount is awarded based on accomplishments within each module.

GRDP participants who apply to a graduate school or a research laboratory are reminded that visiting an institution or facility may enhance an applicant's chances of being offered a desired opportunity. To underscore this point, GRDP reimburses or advances travel expenses to visit a research laboratory or graduate school before or after being offered a position, respectively. These travel grants are limited and the GRDP staff helps participants plan to maximize the travel resources allotted to them. GRDP establishes contact with an administrator, professor, scientist, engineer, or student who may assist the participant in assessing opportunities at the institution or facility. A one-page trip summary of the visit is a responsibility of the participant. Travel is arranged so that academic commitments may be maintained.

GRDP participants who are juniors and accept an internship at a research facility are eligible for GRDP research internship support. On an individual basis, GRDP attempts to provide the difference between a research internship salary and a non-research salary, up to a designated maximum. Brief progress reports or research papers are required to receive the grant throughout the summer.

## Staff

The Boston metropolitan area has provided GRDP with a diverse staff. Each staff member is or has been a graduate student, most in technical disciplines, and has a part-time association with GRDP. For staff which are currently graduate students, GRDP has the secondary benefit of providing them with support for their graduate education. In the three-year history of GRDP, two staff members have been awarded NASA fellowships.

GRDP staff members have had a variety of experiences. Some have had experience in industry. Others were born outside of the United States (Jamaica, Guyana, Japan, Panama). We have had single parents as well as married couples with adult or pre-school children. GRDP thus provides participants with social as well as professional role-models.

## GRDP's Competition

Encouraging the target populations to pursue degrees requiring technical and quantitative skills has been difficult but generally successful. It appears that as a result of attrition at the undergraduate level, a relatively small number of individuals from the target populations receive undergraduate degrees in engineering and science. It is from this small pool that candidates for graduate-level degrees are generally selected.

This pool is also the recruiting source for business and industry. Individuals with undergraduate science and engineering degrees command high salaries from employers seeking people with state-of-the-art skills for various technical positions. Annual salary offers approaching the middle \$30,000 range are not uncommon. Large starting salaries deter many from continuing on to graduate school. Unlike professional fields such as medicine, law, or dentistry, engineering practice generally does not require an advanced degree or licensure. Though professional registration for engineers is often encouraged, many laws allow employers to assume the legal responsibilities for engineering practice. Consequently there is less incentive to attend graduate school.

## Bottom-Up Methodologies

Our experience has shown that our top-down modules may be complemented by a **bottom-up** or event-driven methodology. This approach considers **events** in the academic and professional experiences of participants as a means to guide the development of the personal and leadership skills necessary for graduate school and similar endeavors. We have learned that it is important for GRDP to understand more about each individual participant. To help accomplish this, each staff member serves as a mentor to a participant. Each mentor decides when and how much information to share with other staff about their participant. We often find that similar issues and problems surface in different modules and we become better equipped to deal with them when they are discussed in an open manner.

Our conclusion is that the best strategy for encouraging our target population to consider graduate school is to foster individual interaction with them. It is important for us to understand many of the issues that cause participants to investigate or reject graduate school. These issues include family and

employment pressures, self-esteem and confidence problems, research interests, indecisiveness, academic burnout, etc.

## **Results**

From the approximately 50 people who have participated in GRDP, five have applied to graduate programs. Two have successfully been admitted to graduate school. One individual is employed with a master's degree, and is pursuing her doctorate part-time. She is also the instructor for the program's GRE module. The other participated in GRDP since her junior year and is enrolled full-time in a master's degree program with fellowship support. Two of the remaining three applicants are awaiting decisions on admission and financial aid. One individual was unsuccessful in gaining admission for graduate study. We believe that this was mainly due to her not actively seeking admission for graduate study until the second semester of her senior year. Four of the five were females of Black and/or Hispanic origin who had majored in engineering. The remaining individual was a Black male who majored in engineering technology.

We do not base the success of GRDP solely on the numbers of individuals who attend graduate school. We believe that for undergraduates to include GRDP in their weekly activities is significant. Since GRDP offers no direct benefit to academic pursuits, and offers a modest stipend, participation is an indicator of interest in graduate school. We have had several undergraduates who could not accommodate GRDP in earlier program years, return to GRDP seeking admission.

Quite often we have been told by our participants that GRDP serves as means for social interaction. They felt that GRDP was a comfortable environment where issues could be discussed candidly and straightforward answers and comments could be expected. We were not surprised that our recent graduates would share this perspective. There is limited support provided for our target population by employers. We did not expect this response from undergraduates who were associated with academic, professional, and social support organizations internal and external to their academic institutions. Apparently the existence of sophisticated social avenues for undergraduates does not reduce the need for programs similar to GRDP.

## **Future Issues**

There are several important issues which will be explored in future program years. First, it is not easy to identify how GRDP has had an effect on its participants; for example, whether GRDP supports existing intentions or promotes non-existing aspirations to pursue graduate degrees. Knowing the difference could lead to program designs which allow a program's resources to be used more efficiently and effectively.

Second, profiles need to be established to detect common characteristics of those who attend graduate school and those who do not. We believe that specific identification of factors beyond employment and salaries which cause selection of employment over graduate study would be helpful in deciding how to suggest graduate study earlier in a student's academic career. For example, we need to discover why: (1) fewer males in the target population appear to be applying to graduate school and (2) fewer females apply to technical graduate schools.

Third, an effort is needed to expand the scope of such programs to include more disciplines which are underrepresented by racial and ethnic populations. Many of the details illustrated in this paper may apply for various types of graduate programs. Techniques and strategies which are generally applicable will be very useful for attracting students to graduate programs.

## Summary

From our experiences with GRDP, we have summarized some of the important aspects of the program:

**1. Program setting.** Programs such as GRDP benefit from being housed in academic settings. In large metropolitan areas such as Boston, where there are several academic institutions, a community-based program has the opportunity to attract a diverse undergraduate student population. It also attracts recent graduates from nearby business and industry. University environments also allow recent graduates to become reacquainted to academic surroundings. Commitments from administrative personnel for meeting space, laboratory tours, computer resources, etc., are easier to secure.

**2. Diverse participants.** One of the most receptive audiences for the message of graduate school is the recent graduate. These individuals have the advantage of having experience as a way to measure the importance of a graduate degree. Recent graduates may also be able to influence undergraduates through associations developed within the program. First-year graduate students who continue to require mentoring and skill development should also be invited to participate in programs such as GRDP.

**3. Mentoring.** Mentoring relationships are essential for success in structured and competitive environments. The lack of role models at the graduate level in science and engineering departments often does not allow undergraduates to have the exposure they need. The same can be true in industry where there may not be scientists and engineers who are visible to younger employees. Therefore, the selection of a staff which includes role models who have had experience in graduate school has been critical. The fact that the staff has had experience in both industry and academia has been a plus to the program.

**4. Admissions.** A rolling admissions policy has been essential to the success of the program. Our efforts to structure the program around self-initiative as opposed to a schedule was not only necessary, but provides the participant with a first-hand opportunity to learn to manage the resources necessary to complete the graduate school process. Our admission procedure has increased the workload on staff members, but it has allowed us to attract and retain individuals as soon as they discover the program and its benefits.

**5. Information.** GRDP attempts to maintain an environment where a participant may match his or her level of preparation, skills, and commitment with his or her desire to attend and complete graduate school. The program provides a forum for asking questions about graduate school and the politics of the graduate school process while allowing the participant to simulate different aspects of the graduate school process. There is a constant flow of information in the form of articles, books and presentations which are available to anyone, including non-GRDP participants.